

**APPLICATION
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**TITLE: REAL TIME DATA COMPRESSION METHOD AND
APPARATUS FOR A DATA RECORDER**

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REAL TIME DATA COMPRESSION METHOD AND APPARATUS FOR A DATA RECORDER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is related to a real time data compression method and apparatus applied for a data recorder, and more particularly to a method that possesses superior data compression ability even when data is rapidly varied so that significant storage capacity is available. The compressed data is further stored with a particular format that allows the searching process for these compressed data to become much quicker.

2. Description of Related Arts

In many industrial applications, a variety of data reading must be recorded, such as the temperature reading, pressure value, flow rate or electric power reading, etc. Conventionally, all variations of these readings are stored by a data storage device and printed on paper to observe their possible varying tendency. In recent years, in accordance with the fast development of the microprocessor, a lot of electrical recorders, also known as “paperless recorders”, are presented to replace the conventional recorders.

These paperless recorders usually utilize a memory device to store the recorded data or readings. Since the recording process usually lasts for a quite long time, the memory storage capacity is a vital important factor that must be considered. Although lots of data compression methods are applied to reduce the size of the recorded data to spare a lot of available capacity in memory, these methods still have several shortcomings that need to be solved.

1 For example, one kind of the fan compression methods entitled SASP2 is
2 to examine whether a new reading is in a predetermined tolerable range. If so, the
3 reading is ignored, otherwise the reading will be recorded. With reference to the
4 upper line on Fig. 5, each point located on the line individually represents a
5 sampled data point. The substantially closed fan-shaped region between two
6 adjacent sample points represents the tolerable error range, wherein each
7 tolerable error range is predicted based on the previous data sample point. The
8 compression method is that if the present read data point X_i is in the tolerable
9 range, the previous data point X_{i-1} is ignored. On the contrary, if the present one
10 exceeds the tolerable range, the previous data point is recorded. Another line
11 segment shown in the lower part of Fig. 5 represents actual variations of a series
12 of the read data points.

13 However, the data compression method is capable of providing a
14 superior compression efficiency only when the data variation is slow. When
15 readings are varied rapidly in a period, almost all data points during the period
16 must be recorded its position and value, which leads to the compression
17 becoming inefficient.

18 Furthermore, based on the conventional compression method, the
19 recorded information for a data point include the sampling time, the position and
20 the value of the data point. Based on the present computer recording format, a
21 complete sampling time must be represented by 8 bytes. However, such a format
22 is not only unfavorable for saving the memory capacity, but is also unsuitable to
23 find the desired data by the searching processing.

24 To overcome the mentioned shortcomings, a real time compression

1 method and apparatus for a data recorder in accordance with the present
2 invention obviates or mitigates the aforementioned problems.

3 SUMMARY OF THE INVENTION

4 The main objective of the present invention is to provide a real time
5 compression method and apparatus for a data recorder to effectively compress
6 data even when the data is varied quickly so that more memory capacities are
7 saved.

8 To achieve the objective, the method examines whether a present readin
9 data point is in a predicted tolerable error range. If yes, the previous data point is
10 deemed as redundant and is ignored and after which a new data point is read in
11 for examining again. When such an “ignore” situation repeatedly lasts for a
12 predetermined period, it means the extent of data variation is small and only the
13 final data point is recorded.

14 Otherwise, if multiple continuously examined data points during an
15 examining period all exceed the predetermined tolerable error range, each value
16 of these data points and a total amount value of these data points are recorded.

17 A second objective of the present invention is to provide a compression
18 data structure that is suitable to be employed in the data searching process.

19 To achieve of the objective, the data structure is composed of a main
20 region and a second region.

21 The main region stores two kinds of parameters, where the first
22 parameter is the total amount of the accumulated data points between two
23 recorded data points, and the second parameter represents the values of the
24 recorded data points.

1 The secondary region stores the start time when the data is initially
2 recorded, the sample time interval, the starting time and starting position of each
3 block.

4 In the data searching process, because the secondary region has the
5 starting time of the block, the searching process is firstly performed on the
6 secondary region to find a block that contains the desired data. Based on the
7 known block, the searching process is then performed on the first region to obtain
8 the desired data.

9 It is noted that the starting time of each block recorded in the secondary
10 region, which is relative to the is expressed by the times of the sampling interval
11 relative to the start time when the data is initially recorded. So the starting time is
12 able to be stored in the form of 4 bytes so that the storage capacity is able to be
13 saved.

14 A further objective of the present is to provide a data compression
15 apparatus, which includes:

16 a processing unit to perform the data compression process;

17 an interface unit connected to the processing unit through a connecting
18 interface, wherein the interface unit includes a microprocessor and an A/D
19 converter that converts the measured analog signals to the digital form and then
20 transmits the digital signals to the microprocessor;

21 a storing unit connected to the processing unit through the data/address
22 bus for storing the compressed data.

23 The apparatus is able to connected with a measuring instrument via the
24 interface unit and converts the measured signals to the digital form, then the

1 digital signals are further compressed and stored in the storing unit.

2 The features and structure of the present invention will be more clearly
3 understood when taken in conjunction with the accompanying figures.

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 Fig.1 is a diagrammatic representation of the means of a data
6 compression method in accordance with the present invention;

7 Fig. 2 is a flow chart of the compression method in accordance with the
8 present invention;

9 Fig. 3 shows a data structure in accordance with the present invention;

10 Fig. 4 is block diagram of an apparatus in accordance with the present
11 invention; and

12 Fig. 5 is a diagrammatic representation of the means of a conventional
13 fan method SASP2.

14 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

15 In the present invention, a real time data compression method applied
16 for a data recorder is disclosed. The compressing processing performed on data is
17 deemed as segment by segment, and further based on the variation extent of the
18 data to determine the compression format. In the compression method, a present
19 read data point is examined to determine whether it is in a tolerable error range,
20 where the tolerable error range is predicted based on a previous data point.
21 According to the examined result, the previous data point is determined to be
22 ignored or not. When the data remains steady or the variation extent is small
23 during a period, the quantity of the recorded data points is accordingly less than
24 that when data is rapidly varied. Thus, based on the amount of the recorded data

1 points, the extent of data variation is obtainable so that the compression format is
2 able to change in real time.

3 The real time data compression method for a data recorder that
4 sequentially reads a plurality of sampled data points, the method comprising the
5 steps of:

6 setting the first sampled data point as a starting point X_0 ;

7 sequentially examining the plurality of data points, wherein a present
8 data point X_i being examined is determined whether it is in a predetermined
9 tolerable error range; wherein if the present data point X_i is in the predetermined
10 tolerable error range, a previous data point X_{i-1} is ignored;

11 wherein the previous data point X_{i-1} and the total amount of data points
12 accumulated from the starting point X_0 to the previous data point X_{i-1} are
13 recorded, and the previous data point X_{i-1} is then set as a new starting point,
14 when (a) the present data point X_i exceeds the predetermined tolerable error
15 range or (b) the amount of the ignored data points reaches to a first predetermined
16 amount;

17 wherein during a period that the sampled data points are varied quickly,
18 and when the amount of the continuously examined data points is less than a
19 second predetermined amount, the total amount of the data points that exceed
20 their respective predetermined tolerable error ranges and the value of each of
21 these data point are recorded.

22 In order to explain the present invention in detail, a curve that
23 represents the data variation extent is illustrated in Fig. 1, where the lateral
24 direction represents the time and X_0 to X_{11} each represents a sampled data point

1 during the sampling period from t_0 to t_{11} .

2 When adjacent sampling points are sequentially read, the later one is
3 examined to determine whether it is in a tolerable error range. If so, the previous
4 data point is deemed as a redundant one and is accordingly ignored. In this
5 example, X_0 is a starting point and a fan region R_1 is derived by three points, the
6 X_0 , X_{1+} and X_{1-} , where “ ” is a preset error value. By extending the two lines
7 formed by “ X_0 to X_{1+} ” and “ X_0 to X_{1-} ” to the next data point X_2 , the first
8 predetermined tolerable range R_1 is obtained, wherein the data point X_2 is in the
9 predicted tolerable range so that the previous data point X_1 is able to be ignored.
10 Since X_1 is ignored, a second predetermined tolerable range R_2 is obtained by
11 X_0 , X_{2+} and X_{2-} . Again, because the next data point X_3 is in the second
12 predicted tolerable range R_2 , X_2 is also ignored.

13 During the examining process, the quantity of the ignored data points is
14 compared with a pre-determined value. When the quantity exceeds the pre-
15 determined value, the latest data point is recorded even when it is in the tolerable
16 error range.

17 As shown in Fig. 1, data point X_4 is out of the tolerable range deriving
18 from the X_3 , X_{4+} and X_{4-} .

19 Conventional recording method must stores two parameters, the
20 quantity of data points accumulated from X_0 to X_3 and the value of the data point
21 X_4 . The recording format is expressed in a form of (n_3, X_3) , where n_3 means the
22 quantity from data points X_0 to X_3 . Then, the data point X_3 is used as a new
23 starting point for next round. A new tolerable range applied to examine data point
24 X_5 is derived from data point X_3 , X_{4+} and X_{4-} . In this example, X_5 also

1 exceeds the tolerable range. Still referring to Fig. 1, data points X5 is not in the
2 predicted tolerable range obtained from X3, X4+ and X4- . According to the
3 aforementioned rule, the quantity of the data points from X3 to X4 and the value
4 of X4 must be recorded in the form of (n4, X4), and then the data point X4 is
5 deemed as a new starting point for next round. Similarly, since X6 exceeds the
6 predicted tolerable error range, so (n5, X5) is recorded. With such a conventional
7 data recording format, a lot of memory capacities is required.

8 The present invention improves the conventional method by such a
9 means described hereinafter. When a present data point X_i is examined to
10 determine whether it is in the predicted tolerable range, and it is found that the
11 present data point X_i or one of the two previous data points X_{i-1} , X_{i-2} is not in its
12 predicted tolerable range, the previous data point X_{i-1} is temporarily stored in a
13 register. Once there are three continuous data points are all in their respective
14 predicted tolerable ranges, the data recording means returns to normal and is the
15 same as the conventional means. The total amount of the temporarily stored data
16 points is expressed with a negative number. For example, data points X4 to X7 all
17 exceed their correspondingly tolerable error ranges in Fig. 1, data variation is
18 quite quick in the duration t_4 to t_7 . All the data points from X4 to X7 must be
19 recorded. A recording format for these points is expressed by (-4, X4c, X5c, X6c,
20 X7c). In this format, the first parameter “-4” means the amount of the data points
21 during the period X4 to X7 and is further provided with a negative sign.

22 The other parameters (X4c, X5c, X6c, X7c) respectively represent the
23 values of the data points (X4, X5, X6, X7). Quite obviously, for the data points
24 that have a great extension of variation, since they are not individually expressed

1 by two parameters as performed by the conventional method SASP2, the
2 recorded information is much less and more memory capacities are saved.

3 With reference to Fig. 2, a flow chart of the method is shown. The main
4 steps of which are listed below.

5 1. Read sample points X1 and X2 and set StartPt=X1, EndPt=X2,
6 Buf_count=2 and compression flag=ON;

7 2. Read a new data point X and examine whether the EndPt is
8 redundant;

9 3. If the EndPt is redundant, then

10 (1) If the compression flag is ON, then

11 (i) Examine whether Buf_count has exceeded or is equal to a
12 maximum compression length;

13 (a) If yes, set nData=Buf_count-1, and store nData and
14 EndPt into a storage media. Then set the Buf_count=1.

15 (2) If the compression flag is OFF, then

16 (i) Set nData=-Buf_count, save nData and all data in a buffer
17 into a storage media;

18 (ii) Set StartPt=EndPt;

19 (iii) Set comprssion flag is ON;

20 (3) Set Buf_count=Buf-count+1, EndPt=X;

21 (4) Return to step 2;

22 4. If the EndPt is not redundant, then

23 (1) If Buf_count<=2, then set the compression flag is OFF;

24 (2) If the compression flag is ON, then

- 1 (i) Set $nData = Buf_count - 1$, and store $nData$ and $EndPt$ into a
- 2 storage media;
- 3 (ii) Set $Buf_count = 1$;
- 4 (3) If the compression flag is OFF, then
- 5 (i) Examine whether Buf_count has exceeded or is equal to a
- 6 maximum compression length;
- 7 (a) If yes, set $nData = 1 - Buf_count$, store $nData$ and all data
- 8 in a buffer into a storage media and set $Buf_count = 1$;
- 9 (b) If not, store $EndPt$ to the buffer;
- 10 (4) Set $Buf_count = Buf_count + 1$ and $EndPt = X$;
- 11 (5) Return to step 2;

12 From the foregoing description, $nData$ represents the total quantity of
13 data points calculated between two recorded data points. Thus, if the sampling
14 interval is maintained at constant, $nData$ is deemed as the time between two
15 recorded data points. If the time of a particular recorded data point is intended to
16 know, it can be obtained by sequentially accumulating $nData$ values from the
17 first recorded data point to the expected recorded data point, where the initial
18 time must be added. However, such a calculation way may cause two problems.
19 The first problem is that the calculation process will spend a lot of time if a great
20 quantity of data points are stored. The second problem is that after the data
21 recorder is shut down, there are no data points being stored during the period
22 from the recorder been shut down to be re-activated, and thus $nData$ is unable to
23 precisely represent the time information. To solve the two problems, the present
24 invention provides a particular data structure that is suitable to be applied in the

1 data searching.

2 With reference to Fig. 3, the data structure comprises a main region (10)
3 and a secondary region (20), wherein the main region (10) is composed of
4 multiple segments. Each segment is provided to record two types of parameters,
5 nData and Data, where a “nData” accompanied with a “Data” represent one
6 recorded unit. Each “nData” occupying two bytes representing the amount of the
7 data points, where the amount is calculated between the present recorded data
8 point and the previous recorded data point. Each “Data” parameter with 3 bytes
9 represents the value of the present recorded data point.

10 The secondary region (20) is composed of four types of information, an
11 F_Start_Time occupying 8 bytes, an Smpl_intvl occupying 4 bytes, a plurality of
12 Blk_Start_time each occupying 4 bytes and a plurality of Blk_Start_Pos each
13 also occupying 4 bytes. The F_Start_Time means the time from which the
14 sampling process starts. The Smpl_intvl means a time interval between two
15 sampled data points. A complete block, which corresponds to a group of the
16 recorded points, is composed of two parameters Blk_Start_time and
17 Blk_Start_Pos.

18 The parameter “Blk_Start_time”, which is expressed in the form of
19 multiples of the Smpl_intvl, represents the starting time of the block, wherein the
20 starting time of the block is relative to the F_Start_Time. For example, if the
21 F_Start_Time is zero and the Smpl_intvl is two, the parameter “Blk_Start_time”
22 is expressed as “5” when the starting time of the first block is occurred at ten
23 (10/2=5). Since the parameter “Blk_Start_time”, which is relative to the
24 F_Start_Time, is expressed by the multiples of the Smpl_intvl, the parameter is

1 able to be represented by fewer than eight bytes.

2 To search a desired data, a well known searching technique, such as the
3 Binary Search method, is performed on the foregoing secondary region (20) to
4 find out a particular block where the desired data located. Then, when the
5 Blk_Start_Time of the particular block is obtained, the exact data can be found in
6 the main region (10) based on the Blk_Start_Time.

7 The secondary region (20) is created by the following steps:

8 1. When the data recorder is activated initially and a first sample data
9 point is stored, the time that the first sample data point being recorded is deemed
10 as the start time of a first block (Blk_Start_Time), wherein the parameter
11 Blk_Start_Time is stored into the secondary region (20). Meanwhile the position
12 of the first block (Blk_Start_Pos) is also recorded in the secondary region (20). It
13 is noted that in every time that the recorder is activated again, the first “nData” in
14 the first segment of the first region is set to zero as an identifying symbol, and the
15 value of first recorded data point is stored in the first “Data”.

16 2. In the data compression process, when the stored data points reach to
17 a predetermined amount, a new block is created. The starting time and the
18 position parameter of the new block (Blk_Start_Time) (Blk_Start_Pos) are also
19 recorded into the secondary region (20).

20 In the data decompression process, when the searching process has
21 reached to the end of the previous block (i.e. the start position of the present
22 block, Blk_Start_Pos), an end time of the previous block is able to be calculated.
23 If the end time is less than the Blk_Start_time of the present invention, and
24 “nData” at the beginning of the present block is zero, it can be understood that

1 there is no data points during the end time of the previous block and the starting
2 time of the present block. If the desired data is in the period, an empty-data
3 symbol is employed to show this situation.

4 With reference to Fig. 4, an apparatus for performing the
5 aforementioned method is illustrated. The apparatus comprises a processing unit
6 (30), an interface unit (40), a storing unit (50), a display unit (60) and a power
7 supply unit (70).

8 The processing unit (30) includes a microprocessor (not shown) that
9 connects to a real time clock (32) and a flash memory (33), wherein the real time
10 clock (32) regularly generates an interrupt requirement to inform the processing
11 unit (30) for data recording and compressing. Further, the processing unit (30)
12 has a first serial port (31).

13 The interface unit (40) provides a second serial port (41) to
14 correspondingly connect to the processing unit (30) via the first serial port (31).
15 The interface unit (40) also includes a microprocessor (not shown) and an A/D
16 converter (42) that converts the measured analog signals to the digital form and
17 then transmits the digital signals to the microprocessor. After which, the digital
18 signals are transmitted via the two serial ports (41, 31) to the processing unit (30).

19 The storing unit (50) is connected to the processing unit (30) through
20 the data/address bus for storing the compressed data.

21 The display unit (60) is connected to the processing unit (30) to show
22 the operating status.

23 When the interface unit (40) is connected to a measuring device and
24 receives the measured analog signals generated from the measuring device, these

1 analog signals are converted to the digital form and further output to the
2 processing unit (30) for data compression. These compressed data are then saved
3 in the storing unit (50) for data searching, then the searched result is shown by the
4 display unit (60).

5 From the foregoing description, the method in accordance with the
6 present invention has the advantages of:

7 1. Save significant memory capacities even when data are varied
8 rapidly. Since the conventional fan compression method must save the position
9 and value information of each recorded data point when data is changed quickly,
10 a large storing capacity is required. However, the present invention does not
11 record the position information of each recorded data point, so significant
12 memory capacities are saved.

13 2. The searching efficiency is able to be improved. The present
14 invention utilizes a secondary region to represent the compressed data in the form
15 of block. Thus, when the searching process is firstly performed on the secondary
16 region, a particular block that contains the information of the desired data is able
17 to be found easily. Then based on the block, the desired data is easily acquired.

18 The foregoing description of the preferred embodiments of the present
19 invention is intended to be illustrative only and, under no circumstances, should
20 the scope of the present invention be restricted by the description of the specific
21 embodiment.